Carbon-Aerogel Capacitive Deionization of Water

An efficient, economical process for purifying water

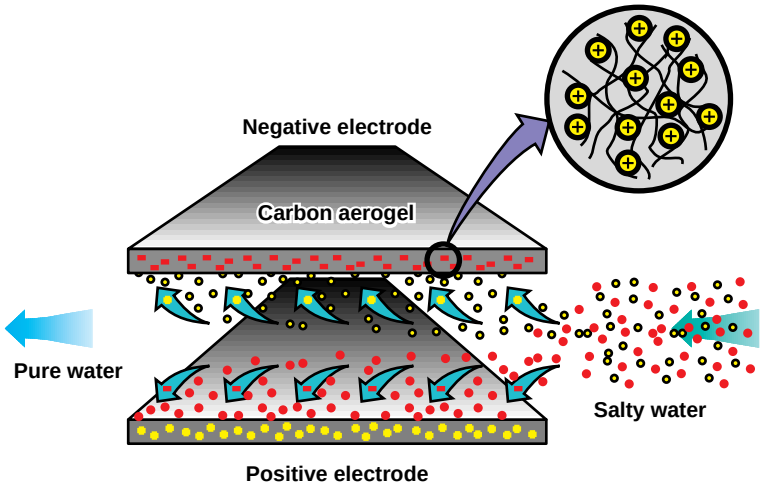
R&D 100

Capacitive deionization (CDI) with carbon-aerogel electrodes is an efficient and economical new process for removing salt and impurities from water. In the process, water is passed between electrodes kept at a potential difference of about one volt; nonreducible and nonoxidizable ions are removed from the water by the imposed electrostatic field and held at the electrode surfaces. When the electrodes become saturated with salt, they are electrostatically "regenerated," releasing the salts into a concentrated purge stream.

Carbon-aerogel electrodes have excellent stability in harsh chemical conditions and a very high specific surface area (600–1000 square meters per gram of aerogel), which enables the design of robust yet compact purifying systems. Carbon aerogels were developed at LLNL, and are now in commercial production. Their cost should drop considerably as their use in this and other applications increases. Some of the energy used in ion removal can be recovered during regeneration, improving overall energy efficiency.

APPLICATIONS

- *Brackish water/sea water desalination*
- *Treatment of heat exchanger and boiler water, industrial and commercial process water and ultrapure industrial water*
- *Industrial waste water*
- *Municipal waste water*
- *Mixed hazardous and/or radioactive waste*
- *Mineral extraction*
- *Medical*
- *Domestic water softeners and refined drinking water treatment*
- *Analytical instrumentation*



In the CDI process, salty water enters space between two carbon-aerogel electrodes; electrostatic field forces sodium and chlorine ions into aerogel, where they are held (inset); pure water leaves the space between the electrodes.

Advantages

The system has a simple, modular, plate-and-frame construction. It uses simple electrostatic regeneration, compared to ion-exchange systems that require acids, bases, or salt solutions for regeneration. CDI does not require the use of membranes or high-pressure pumps, which means the equipment is much more resistant to the effects of corrosive liquids (used to remove scale) than in other methods. And, CDI is more energy-efficient than competing technologies—far more efficient than thermal processes.

Our demonstration system has eight cells, containing 384 pairs of carbon-aerogel electrodes with a total surface area of more than two billion square centimeters (about 54 acres); yet the system occupies only a few cubic feet of space.

Energy efficiency. Brackish water (salt content of 800–3200 parts per million [ppm]) is conventionally purified using electrodialysis or reverse osmosis. Carbon-aerogel CDI uses 10–20 times less energy per gallon of purified water to achieve the same results. Purification of brackish water is an extremely important potential application of this technology.

For purifying seawater (32,000 ppm salt), carbon-aerogel CDI is just as energy-efficient as reverse osmosis, but without the need for costly and troublesome membranes.

Availability: The CDI patent was issued in 1995. The Laboratory is actively looking for industrial partners with whom to further develop and scaleup the technology.

Contact

Jeff Richardson
Phone: (510) 423-5187
Fax: (510) 423-4967
E-mail: richardson6@llnl.gov
Mail code: L-353